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WRITE-ONCE OPTICAL RECORDING MEDIUM
Tsuiki gata hikari kiroku baitai

Mikio Kinoshita et al.

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INVENTORS	(72):	Mikio Kinoshita et al.
APPLICANT	(71):	000006747 Ricoh Co., Ltd.
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Claims

1. A write-once optical recording medium characterized by the following facts: the write-once optical recording medium has at least a semitransparent layer on a substrate, an optical interference layer on the semitransparent layer, and a recording layer on the optical interference layer; and the recording layer consists of a first recording layer made of metal, semi-metal or an alloy, and a second recording layer made of Ge.

2. The write-once optical recording medium described in Claim 1 characterized by the fact that modulation is 60% or higher.

3. The write-once optical recording medium described in Claim 1 or 2 characterized by the fact that the first recording layer is made of Au, Cu, Ag or an alloy, and the film thickness of said first recording layer is 30 nm or thinner.

4. The write-once optical recording medium described in Claim 1 or 2 characterized by the fact that the first recording layer is made of Al or an alloy, and the film thickness of the first recording layer is 20 nm or thinner.

5. The write-once optical recording medium described in Claim 3 or 4 characterized by the fact that the recording layer has a configuration in which the first recording layer is arranged on the side near the incident surface of the read light, and the reflectivity of the recording mark portion is decreased.

6. The write-once optical recording medium described in Claim 2, 3, 4 or 5 characterized by the fact that the optical interference layer has a refractive index of n , a film thickness of d and a recording wavelength of λ , in the following ranges:

$$\begin{aligned} 1. & 1.9 \leq n \leq 2.5 \\ 0. & 25 \leq nd/\lambda \leq 0.35 \\ & 600 \text{ nm} \leq \lambda \leq 680 \text{ nm} \end{aligned}$$

7. The write-once optical recording medium described in Claim 2, 3, 4 or 5 characterized by the fact that the optical interference layer has a refractive index of n , a film thickness of d and a recording wavelength of λ , in the following ranges:

$$\begin{aligned} 1.4 \leq n < 1.6 \\ 0.33 \leq nd/\lambda \leq 0.41 \\ 600 \text{ nm} \leq \lambda \leq 680 \text{ nm} \end{aligned}$$

8. The write-once optical recording medium described in Claim 2, 3, 4 or 5 characterized by the fact that the optical interference layer has a refractive index of n , a film thickness of d and a recording wavelength of λ , in the following ranges:

$$\begin{aligned} 1.6 \leq n \leq 1.9 \\ 0.31 \leq nd/\lambda \leq 0.37 \\ 600 \text{ nm} \leq \lambda \leq 680 \text{ nm} \end{aligned}$$

9. The write-once optical recording medium described in Claim 6 characterized by the fact that the semitransparent layer is made of Au or Ag, and the semitransparent layer has a film thickness in the range of 5-15 nm.

10. The write-once optical recording medium described in Claim 6 characterized by the fact that the semitransparent layer is made of Al, and the Al film thickness is in the range of 1-2 nm.

Detailed explanation of the invention

[0001]

Technical field of the invention

The present invention pertains to a write-once optical recording medium that allows recording/reproduction by means of irradiation of a laser beam or the like.

[0002]

Prior art

The recordable optical recording media using laser beam irradiation include CD-R, DVD-R and other write-once optical recording media. These phase-change optical recording media have reproduction compatibility with CD-ROM and DVD-ROM, and they are used as small scale distribution media and storage media.

[0003]

Problems to be solved by the invention

An especially important topic is to realize a recording density equal to that of DVD-ROM, a large capacity medium. In order to have this widely adopted in applications, guaranteeing the receiving power margin in a high-density recording density is an important topic. In order to guarantee such a property, the phase change recording material, a 2-layer film that allows formation of alloy, and other inorganic recording materials are beneficial. Insufficiency of the modulation, insufficient tracking signal intensity of the drive using DVD-ROM or other DPD (Differential Phase Detection) are also problems to be solved. Especially, for the Al-Ge₂ layer film disclosed in Japanese Kokai Patent Application No. Hei 6[1994]-171236, the reflectivity after heat treatment rises. However, with respect to realization of ROM compatibility, the reflectivity after heat treatment decreases, and obtaining of said 60% or higher modulation is a topic to be addressed for the optical recording media using AlGe₂.

[0004]

Means to solve the problems

The present invention provides a write-once optical recording medium characterized by the following facts: the write-once optical recording medium has at least a semitransparent layer on a substrate, an optical interference layer on the semitransparent layer, and a recording layer on the optical interference layer; and the recording layer consists of a first recording layer made of metal, semi-metal or an alloy, and a second recording layer made of Ge that can form an alloy with the first recording layer.

[0005]

The materials of the first recording layer include Al, Au, Ag, Cu, Pt, Pd, Sb, Te, In, Sn, Zn, etc. as well as their compounds and alloys. The materials of the substrate include polycarbonate, glass, and other conventional transparent materials. Examples of the semitransparent layer formed on the substrate include semitransparent Al thin film, semitransparent Au thin film, semitransparent Si thin film, and other semitransparent materials having absorption, prescribed transmissivity and prescribed reflectivity. It is also possible to make use of a phase change material as the semitransparent layer. Examples of the optical interference layer include ZnS, SiO₂, SiO₂, MgF₂, Si-N, In-O, Zn-C, and other well known dielectric materials. The second [portion] of the present invention is that the modulation is 60% or higher.

[0006]

Claim 3 pertains to the write-once optical recording medium characterized by the fact that the first recording layer is made of Au, Cu, Ag or their alloy, and the film thickness of said first recording layer is 30 nm or thinner. Claim 4 pertains to the write-once optical recording medium characterized by the

fact that the first recording layer is made of Al or its alloy, and the film thickness of the first recording layer is 20 nm or thinner.

[0007]

In addition, Claim 5 pertains to the write-once optical recording medium characterized by the fact that the recording layer has a configuration in which the first recording layer is arranged on the side near the incident surface of the read light, and the reflectivity of the recording mark portion is decreased.

[0008]

Claim 6 pertains to the write-once optical recording medium described in Claim 2, 3, 4 or 5 characterized by the fact that the optical interference layer has a refractive index of n , a film thickness of d and a recording wavelength of λ , in the following ranges:

$$\begin{aligned} 1.9 \leq n \leq 2.5 \\ 0.25 \leq nd/\lambda \leq 0.35 \\ 600 \text{ nm} \leq \lambda \leq 680 \text{ nm} \end{aligned}$$

[0009]

Claim 7 pertains to the write-once optical recording medium described in Claim 2, 3, 4 or 5 characterized by the fact that the optical interference layer has a refractive index of n , a film thickness of d and recording wavelength of λ , in the following ranges:

$$\begin{aligned} 1.4 \leq n < 1.6 \\ 0.33 \leq nd/\lambda \leq 0.41 \\ 600 \text{ nm} \leq \lambda \leq 680 \text{ nm} \end{aligned}$$

[0010]

Claim 8 pertains to the write-once optical recording medium described in Claim 2, 3, 4 or 5 characterized by the fact that the optical interference layer has a refractive index of n , a film thickness of d and a recording wavelength of λ , in the following ranges:

$$\begin{aligned} 1.6 \leq n < 1.9 \\ 0.31 \leq nd/\lambda \leq 0.37 \\ 600 \text{ nm} \leq \lambda \leq 680 \text{ nm} \end{aligned}$$

[0011]

Claim 9 pertains to the write-once optical recording medium described in Claim 6 characterized by the fact that the semitransparent layer is made of Au or Ag, and the semitransparent layer has film thickness in the range of 5-15 nm. Claim 6 pertains to the write-once optical recording medium described in Claim 6 characterized by the fact that the semitransparent layer is made of Al, and the Al film thickness is in the range of 1-2 nm.

[0012]

Function

According to the present invention, there is an optical interference layer in front of the recording layer. The function of the optical interference layer is control of the modulation and the reflectivity. The aforementioned operation is increased by including a semitransparent layer between the substrate and the optical interference layer.

[0013]

There exists a certain relationship between the film thickness and refractive index of the preferable optical interference layer. Also, the light absorptive layer preferably has a small real portion and an

appropriately large imaginary portion of the refractive index. Here, the preferable range of the film thickness of the light absorptive layer significantly depends on the optical constant of the light absorptive layer.

[0014]

The order in laminating the first recording layer and the second recording layer may be selected at will. However, the order defines the variation in the reflectivity in recording. From the viewpoint of compatibility with DVD-ROM, the reflectivity of the recording mark portion should be decreased. This is realized by means of the layer configuration of the recording layer in which the first recording layer is arranged on the side near the incident plane of light. In this case, if the film thickness of the first recording layer is too large, the light absorption decreases and thermal diffusion increases, so that the recording sensitivity deteriorates, or increase in jitter becomes a problem. There is a preferable film thickness of the recording layer. Also, the film thickness values of the first recording layer and the second recording layer are parameters pertaining to the amplitude and phase difference of the reflected light due to the recording layer before and after alloy formation, and they influence the modulation, etc.

[0015]

Embodiment of the invention

Figure 1 is a diagram illustrating the layer structure of the write-once optical recording medium for use in the present invention. Here, on polycarbonate substrate (1), the following layers are sequentially laminated: light absorptive layer (2), optical interference layer (3), recording layer (4) consisting of first recording layer (104) and second recording layer (105), and environment protection layer (5). Here, light absorptive layer (2) is made of Au or Al. Said optical interference layer (3) is made of ZnS/SiO₂ or SiO₂.

Said first recording layer (104) is made of Au, Ag, Cu, Al or the like. Said second recording layer (105) is made of Ge. With this constitution, the reliability of the mark portion after recording decreases. The track pitch of the substrate is 0.74 μm .

[0016]

Table 1 lists the data of the relationship of the reflectivity and modulation on the film thickness of the second recording layer for the write-once optical recording medium of this constitution in recording operation with recording wavelength at 635 nm, recording linear velocity of 7 m/s, data bit length of 0.267 $\mu\text{m/bit}$. Table 1 has the following conditions: the film thickness of light absorptive layer (2) made of Au is 7 nm, the film thickness of optical interference layer (3) made of ZnS/SiO₂ is 95 nm, the film thickness of first recording layer (104) made of Al is 10 nm, and the recording/reproduction wavelength is 635 nm. Large values of modulation are obtained near 50 nm and near 100 nm of second recording layer (105). Because Ge has relatively larger real portion of the refractive index and relatively small absorptivity, Ge itself works as an interference layer, and it influences the reflectivity and modulation, as well as the phase difference of the reflected light between the recorded state and unrecorded state. In order to make improvement in jitter or the like, one may also adopt a scheme in which an extra heat releasing layer or interference layer is deposited on the Ge layer.

[0017]

TABLE 1

a

半透射層Au(7nm)、光干渉層ZnS/SiO₂(95nm)

b

	第1記録層材料	第1記録層膜厚(nm)	第2記録層膜厚(nm)	反射率(%)	振幅変調率(%)
比較例1	Al	10	0	28.6	6.9
実施例1	Al	10	16	14.0	25.0
実施例2	Al	10	26	23.8	50.9
実施例3	Al	10	36	36.0	69.3
実施例4	Al	10	50	50.9	77.2
実施例5	Al	10	76	61.0	70.0
実施例6	Al	10	100	60.1	78.1

c

b

Key:	a	The semitransparent layer is made of A[illegible] at 7 nm, and the optical interference layer is made of ZnS/SiO ₂ at 95 nm
	b	First recording layer material
		First recording layer thickness (nm)
		Second recording layer (Ge) thickness (nm)
		Reflectivity (%)
		Modulation (%)
	c	Comparative Example 1
		Application Example 1
		Application Example 2
		Application Example 3
		Application Example 4
		Application Example 5
		Application Example 6

[0018]

Table 2 lists the data regarding the relationship of the modulation and reflectivity on the film thickness of the first recording layer when first recording layer (104) is made of Ag. It can be seen that when the film thickness of Ag is over 30 nm, the modulation decreases. As far as the recording sensitivity is concerned, due to the thermoconduction and light absorptivity of the recording layer, it is preferred that the Ag film thickness be thinner. That is, when the film thickness of the first recording layer made of Ag is thick, the absorptivity of the recording laser beam decreases, and the thermal

diffusion caused by thermoconduction increases, so that a higher energy is needed to perform heating. In consideration of this feature, it is preferred that the Ag film thickness be 30 nm or thinner.

[0019]

TABLE 2

a

半透明層Ag/7nm, 光学干渉層ZnS/SiO₂/95nm

b

	第1記録層材料	第1記録層厚さ(nm)	第2記録層(Ge)厚さ(nm)	反射率(%)	モジュレーション(%)
比較例2	Ag	0	30	18.6	0.0
実施例7	Ag	5	30	21.0	38.7
実施例8	Ag	10	30	23.0	75.0
実施例9	Ag	15	30	24.3	71.4
実施例10	Ag	20	30	24.9	73.0
実施例11	Ag	25	30	25.8	73.7
実施例12	Ag	30	30	26.2	73.8

c

- Key:

a

The semitransparent layer is made of A[illegible] at 7 nm, and optical interference layer is made of ZnS/SiO₂ at 95 nm

b

First recording layer material
First recording layer thickness (nm)
Second recording layer (Ge) thickness (nm)
Reflectivity (%)
Modulation (%)

c

Comparative Example 2
Application Example 7
Application Example 8
Application Example 9
Application Example 10
Application Example 11
Application Example 12

[0020]

Table 3 lists the data regarding the relationship of the modulation and reflectivity on the film thickness of the first recording layer when the first recording layer is made of Al. Al has a higher absorptivity than Ag, and the thin film corresponding to the maximum modulation is about 20 nm. Just as aforementioned, from the viewpoint of recording sensitivity, it is preferred that the film thickness of Al film be 20 nm or thinner.

[0021]

TABLE 3

a

半透明層Al(7nm), 光学干渉層ZnS/SiO₂(95nm)

b

	第1記録層材料	第1記録層厚さ(nm)	第2記録層(Ge)厚さ(nm)	反射率(%)	モジュレーション(%)
c	実施例13	Al	5	25.7	52.8
	実施例14	Al	10	35.8	68.8
	実施例15	Al	15	42.0	79.0
	実施例16	Al	20	43.4	71.0
	実施例17	Al	30	44.3	66.8
	実施例18	Al	50	46.2	59.7

- Key:
- a

The semitransparent layer is made of A[illegible] at 7 nm, and optical interference layer is made of ZnS/SiO₂ at 95 nm
- b

First recording layer material

First recording layer thickness (nm)

Second recording layer (Ge) thickness (nm)

Reflectivity (%)

Modulation (%)
- c

Application Example 13

Application Example 14

Application Example 15

Application Example 16

Application Example 17

Application Example 18

[0022]

Table 4 lists the data regarding the reflectivity and modulation when the optical interference layer is made of a ZnS/SiO₂ thin film that has a refractive index of 2.17 at a recording wavelength of 635 nm. Here, the first recording layer is made of Al and has a film thickness of 10 nm, and the second recording layer is made of Ge and has a film thickness of 30 nm. The maximum value of modulation takes place near film thickness of the optical interference layer of 85 nm, and the value of modulation is 60% or higher in the range of nd/λ of 0.25-0.35.

[0023]

TABLE 4

a 第一記録層Al10nm、第二記録層Ge30nm		b			
c	半透明層Au膜厚(nm)	光学干渉層ZnS/SiO ₂ 膜厚(nm)	nd/λ	反射率(%)	モジュレーション(%)
	5	55	0.188	85.5	44.8
	7	65	0.222	88.2	55.4
	7	75	0.256	92.9	61.7
	7	85	0.290	97.8	72.3
	7	95	0.325	99.0	80.0
	7	100	0.333	99.7	80.0
	7	115	0.383	98.0	59.0

Key: a The first recording layer is made of Al and has a thickness of 10 nm, the second recording layer is made of Ge and has a thickness of 30 nm

b Thickness of semitransparent layer made of Au (nm)

Thickness of optical interference layer made of ZnS/SiO₂ (nm)

- nd/λ
- Reflectivity (%)
- Modulation (%)
- c Application Example 19
- Application Example 20
- Application Example 21
- Application Example 22
- Application Example 23
- Application Example 24
- Application Example 25

[0024]

Table 5 lists the data about the reflectivity and modulation when the optical interference layer is made of SiO₂ thin film that has a refractive index of 1.457 at a recording wavelength of 635 nm. The maximum value of modulation takes place near a film thickness of the optical interference layer of 160 nm, and the value of modulation is 60% or higher in the range of nd/λ of 0.33-0.41.

[0025]

TABLE 5

a		b				
第1記録層Al10nm、第2記録層Ge20nm						
c	光学膜厚Al10nm	光学膜厚Ge20nm	nd/λ	反射率(%)	透過率(%)	
	10	120	0.280	42.0	50.0	
	10	145	0.333	55.0	30.0	
	10	160	0.367	63.0	24.0	
	10	175	0.400	68.0	21.0	
	10	190	0.430	70.0	18.7	

- Key: a The first recording layer is made of Al and has a thickness of 10 nm, the second recording layer is made of Ge and has a thickness of 30 nm
- b Thickness of semitransparent layer made of Au (nm)
 Thickness of optical interference layer made of SiO₂ (nm)
 nd/λ
 Reflectivity (%)
 Modulation (%)
- c Application Example 26
 Application Example 27
 Application Example 28
 Application Example 29
 Application Example 30

[0026]

Table 6 lists the data about the reflectivity and modulation when the optical interference layer is made of Al₂O₃ thin film that has a refractive index of 1.766 at a recording wavelength of 635 nm. The maximum value of modulation takes place near a film thickness of the optical interference layer of 120 nm, and the value of modulation is 60% or higher in the range of nd/λ of 0.31-0.37.

[0027]

TABLE 6

	a 第1記録層Al10nm、第2記録層Ge30nm		b			
	半透明層Au膜厚(nm)	光学干渉層Al ₂ O ₃ 膜厚(nm)	nd/λ	反射率(%)	モジュレーション(%)	
c	実施例31	8	90	0.753	43.3	44.1
	実施例32	8	190	0.878	39.5	32.7
	実施例33	8	110	0.805	39.8	36.0
	実施例34	8	180	0.824	38.9	36.0
	実施例35	8	130	0.882	37.1	32.3
	実施例36	8	140	0.889	43.4	34.8
	実施例37	8	150	0.413	49.7	40.3

- Key: a The first recording layer is made of Al and has a thickness of 10 nm, the second recording layer is made of Ge and has a thickness of 30 nm
- b Thickness of semitransparent layer made of Au (nm)
- Thickness of optical interference layer made of Al₂O₃ (nm)
- nd/λ
- Reflectivity (%)
- Modulation (%)
- c Application Example 31
- Application Example 32
- Application Example 33
- Application Example 34
- Application Example 35
- Application Example 36
- Application Example 37

[0028]

Table 7 lists the data regarding the dependence of the reflectivity and modulation on the film thickness of the semitransparent layer when the semitransparent layer is made of Au. For the recording layer, the first recording layer is made of Al and has a thickness of 10 nm, and the second recording layer is made of Ge and has a thickness of 30 nm. The value of modulation is 60% or higher in the range of Au film thickness of 5-15 nm.

[0029]

TABLE 7

a 第1記録層Al10nm、第2記録層Ge30nm						
c	半透明層Au膜厚(nm)	光学干渉層ZnS/SiO ₂ 膜厚(nm)	nd/λ	反射率(%)	调制率(%)	
	5	55	0.155	30.4	59.1	59.1
	5	55	0.325	44.1	55.4	55.4
	5	55	0.375	39.5	53.6	53.6
	7	55	0.325	35.0	58.0	58.0
	10	55	0.325	28.8	78.3	78.3
	15	55	0.325	18.8	81.2	81.2
b	20	55	0.325	11.2	88.8	88.8

- Key: a The first recording layer is made of Al and has a thickness of 10 nm, the second recording layer is made of Ge and has a thickness of 30 nm
- b Thickness of semitransparent layer made of Au (nm)
- Thickness of optical interference layer made of ZnS/SiO₂ (nm)
- nd/λ
- Reflectivity (%)
- Modulation (%)
- c Comparative Example 2
- Application Example 38
- Application Example 39

Application Example 40

Application Example 41

Application Example 42

Application Example 43

[0030]

Table 8 lists the data pertaining to the dependence of the reflectivity and modulation on the film thickness of the semitransparent layer when the semitransparent layer is made of Al. Here, the recording layer consists of a first recording layer made of Al with a thickness of 10 nm and a second recording layer made of Ge with a thickness of 30 nm. The modulation is over 60% when the Al film thickness is 1-2 nm. In addition, it is possible to make use of AgInSbTe, GeSbTe, or other phase change materials in making the semitransparent layer. However, in such case, the semitransparent layer is crystallized by the thermal energy in recording. Consequently, the optical constant varies, and it also displays a function as an auxiliary recording layer.

[0031]

TABLE 8

a 第1記録層Al:10nm, 第2記録層Ge:30nm					
c	半透明層Al膜厚(nm)	光干渉層ZnSSiO ₂ 膜厚(nm)	反射率	反射率	反射率
	0	25	0.325	53.1	50.0
	1	25	0.325	33.8	64.8
	2	25	0.325	19.4	68.8
	3	25	0.325	7.0	45.0
	5	25	0.325	17.0	0.0

Key: a The first recording layer is made of Al and has a thickness of 10 nm, the second recording layer is made of Ge and has a thickness of 30 nm

- b Thickness of semitransparent layer made of Al (nm)
Thickness of optical interference layer made of ZnS/SiO₂ (nm)
 nd/λ
Reflectivity (%)
Modulation (%)
- c Comparative Example 3
Application Example 44
Application Example 45
Application Example 46
Application Example 47

[0032]

As explained above, according to the present invention, for the optical recording medium having a first recording layer that can form an alloy with Ge, a modulation of 60% or higher can be obtained with a layer constitution that has the reflectivity decreased in the recording state. In addition, the layer constitution of the optical recording medium for use in the present invention is not limited to the aforementioned constitution. Any structure of the well known optical recording media may be adopted.

[0033]

Effect of the invention

For the present invention with the aforementioned constitution, the following effect can be realized. The modulation of the inorganic base write-once optical recording medium with excellent power margin

can be increased, and it is possible to obtain a write-once optical recording medium that allows reproduction with a general purpose DVD-ROM driver or the like.

Brief description of the figures

Figure 1 is a diagram illustrating the layer constitution of the write-once optical recording medium of the present invention.

Explanation of symbols

- 1 Polycarbonate substrate
- 2 Light absorptive layer
- 3 Optical interference layer
- 4 Recording layer
- 5 Environment protection layer
- 104 First recording layer
- 105 Second recording layer

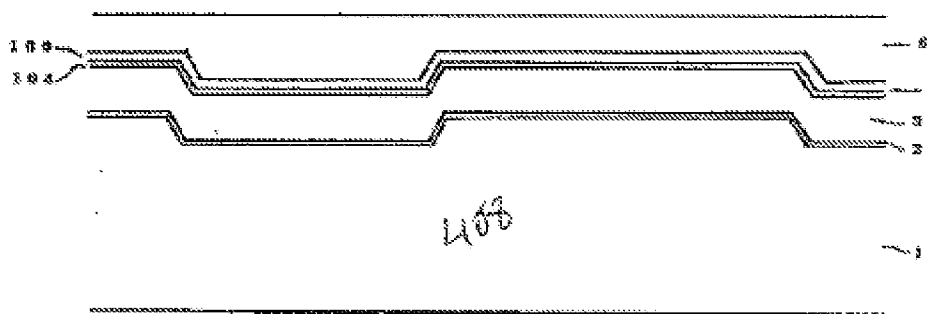


Figure 1